EDS Blois 2019: The 18th conference on Elastic and Diffractive Scattering XVth Rencontres du Vietnam

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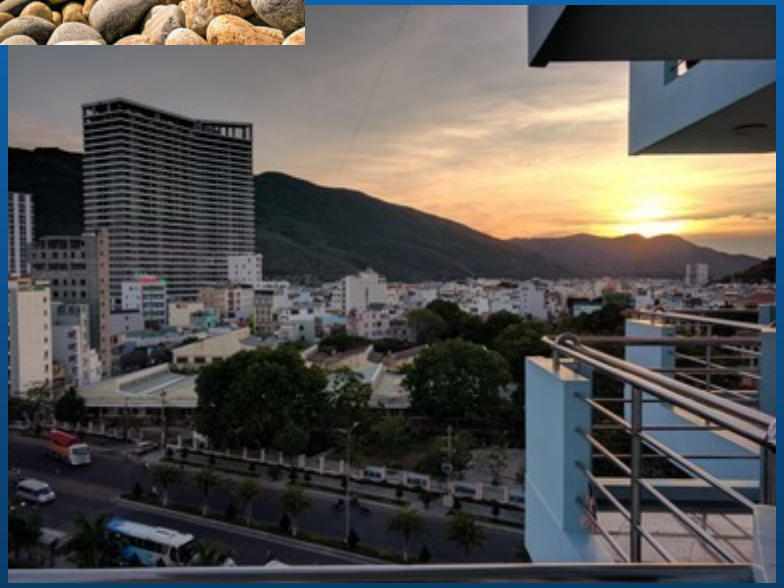
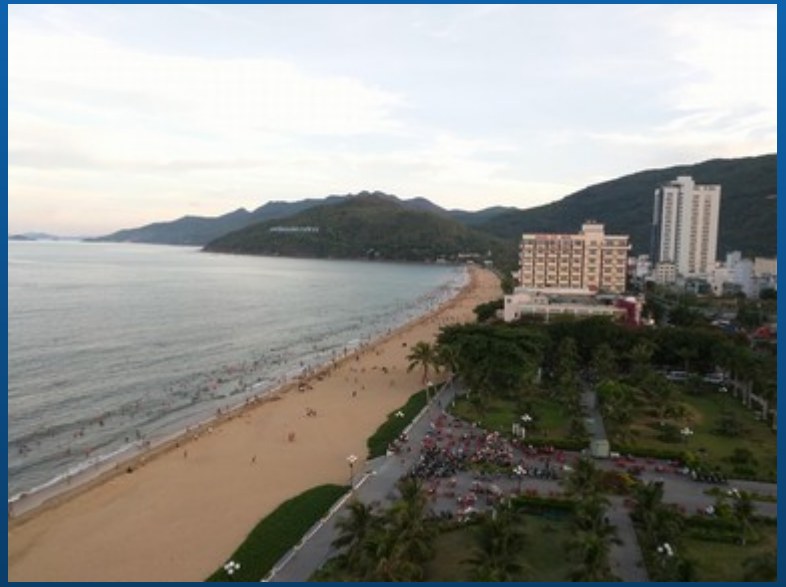




EDS2019

43 talks!

Diffraction and
Central Exclusive Production

MPI

High pT
final states

PDFs

Elastic Scattering &
Total Cross-Section

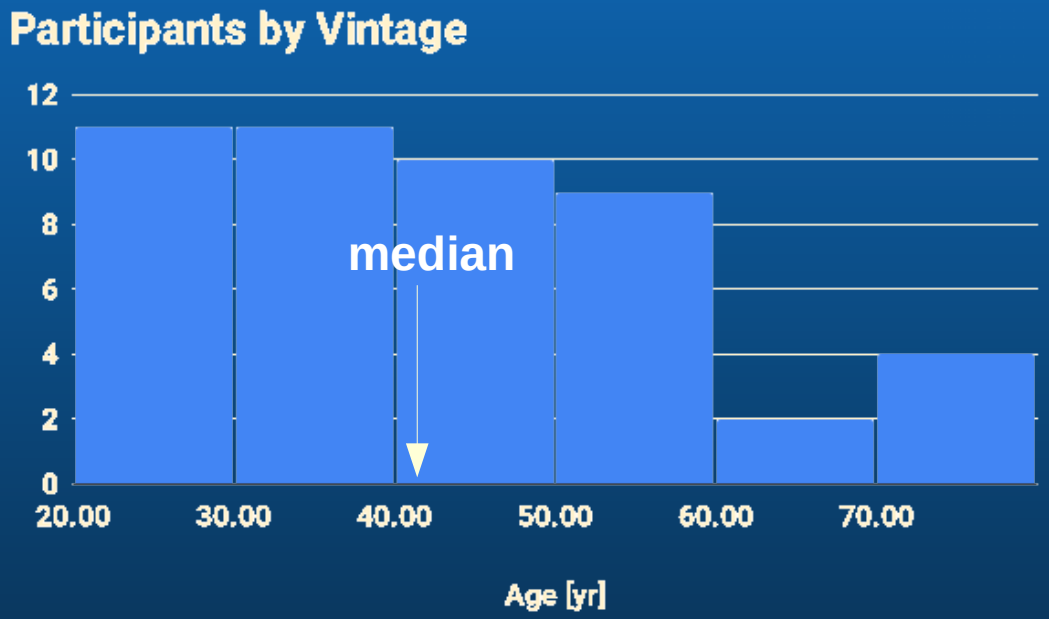
Recent
theoretical
developments

Soft QCD

3D structure
of proton

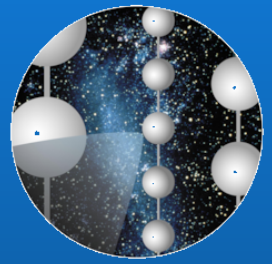
Heavy Ions

Astrophycis,
Ultra High Energy Interactions



EDS2019: Demographics

EDS2019: Experiments



Also future experiments and facilities!

Mea Culpa / Disclaimer

Apologies in advance for misrepresentations and omissions that are unavoidable when covering so many topics by so many experts in their fields.

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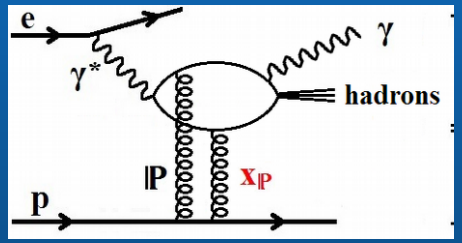
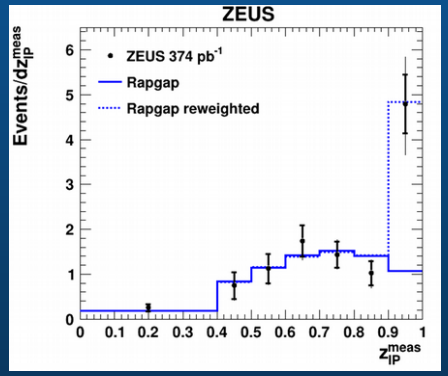
Diffraction and Elastic Scattering

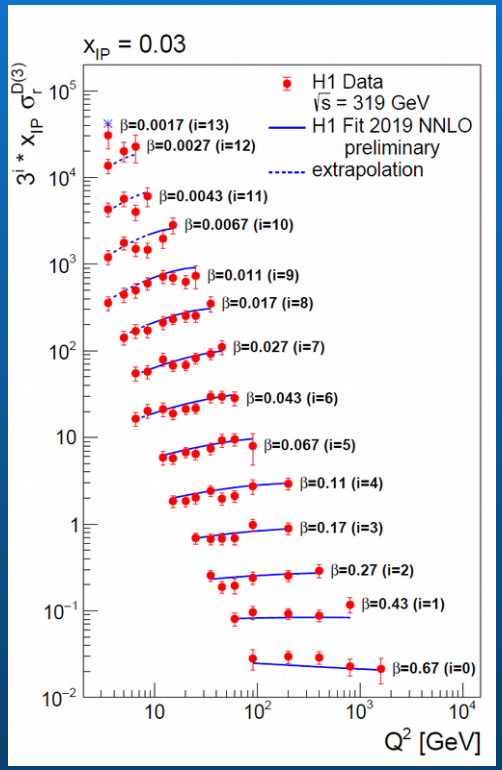




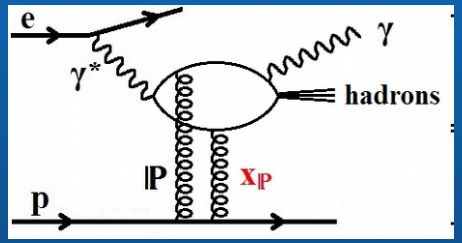
Peter Bussey
- Diffractive γ + jets in ZEUS data!

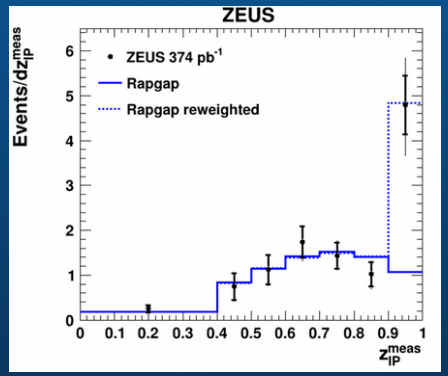
- Evidence: Direct IP interaction

- exclusive production measurements and (D)PDFs



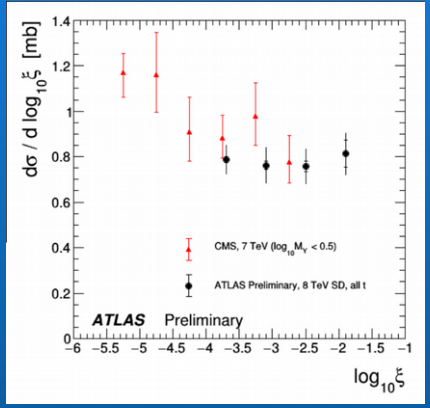
Diffraction and Elastic Scattering



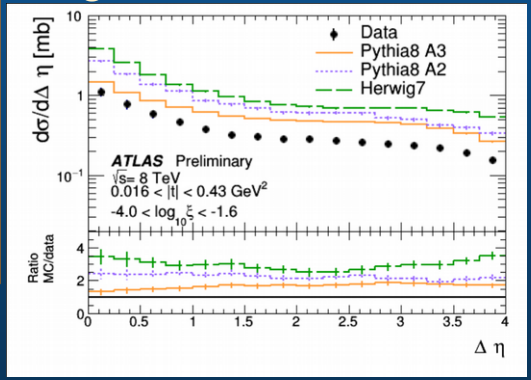


Peter Bussey
- Diffractive γ + jets in ZEUS data!
- Evidence: Direct IP interaction
- (D)PDFs

Leszek Adamczyk
- single diffraction w/ (1st!) fwd proton tagging (ATLAS)
- shapes of ξ, t, gap Δη ~qualitatively agree w/ models



SD XS @ CMS+ATLAS: good agreement in overlap region



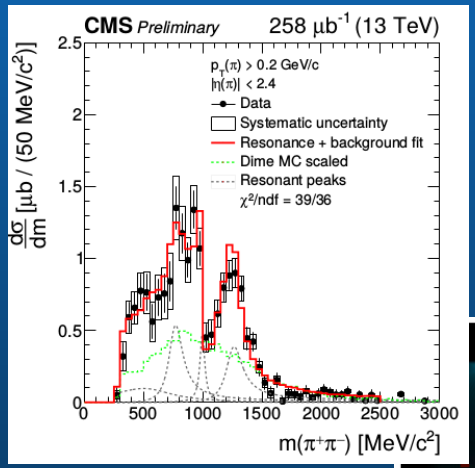
Diffraction and Elastic Scattering

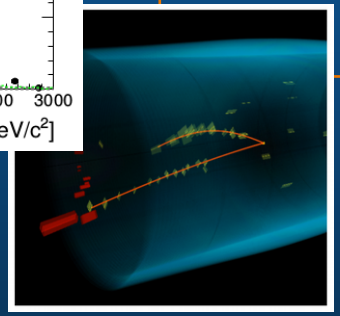
NEW!

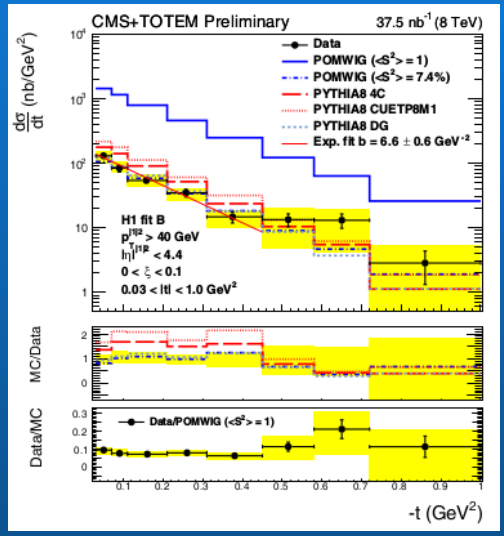
Oliver Suranyi

- CMS Exclusive dipion production at 5.02 and 13 TeV

- CMS and CMS-TOTEM results on diffraction and exclusive production
  - Single diffractive dijets with proton tagging at 8 TeV



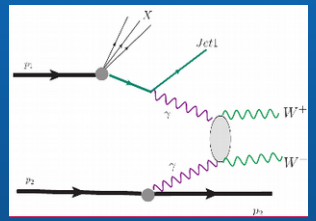


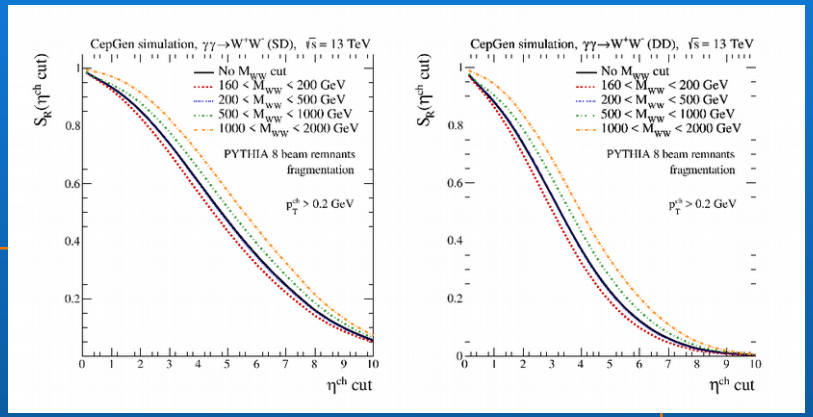


- Good agreement with Pythia 8 DG model and Pomwig

-Scaling with √s as expected from CDF results

Photon collisions

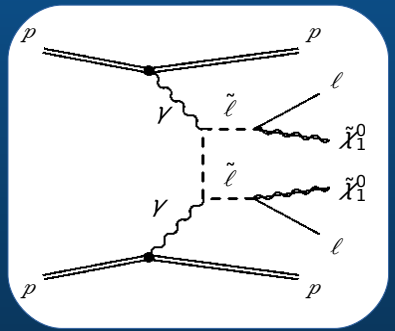


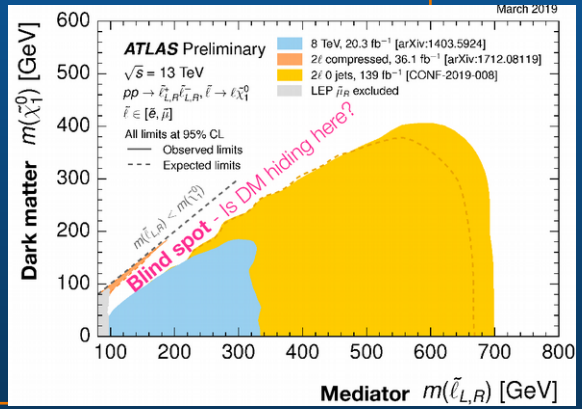


Marta Łuszczak
- $\gamma\gamma$ production of heavy particles (WW,tt)
- Including survival factors for gaps in SD and DD events

Lydia Beresford, Lucian Harland-Lang
- Using Photon Collisions to Search for Dark Matter
- "Living the dream"

Probe initial state & full MET 4-vector
Impossible in usual LHC searches!
- Technically challenging to reduce bkg at high pileup (precision timing?)

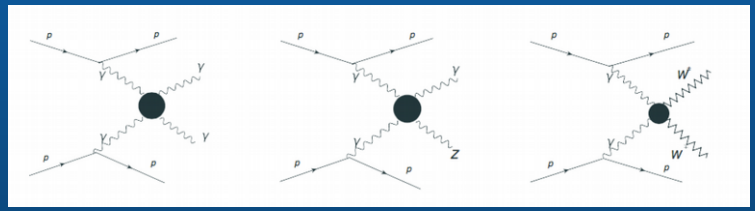




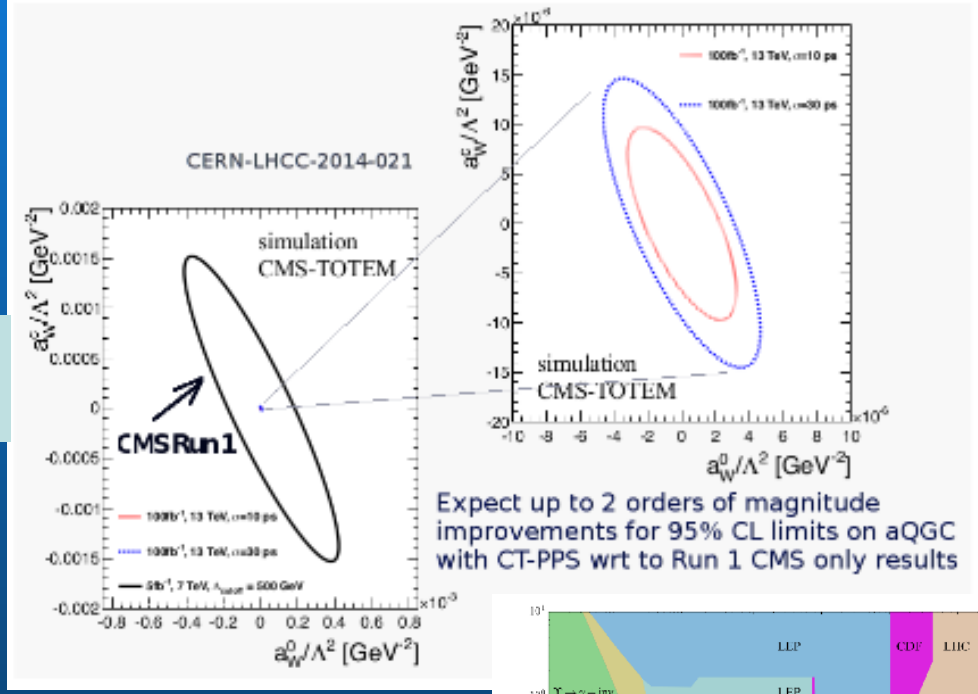
CMS PPS Results and Prospects

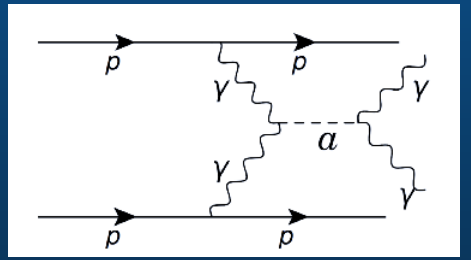
Justin Williams

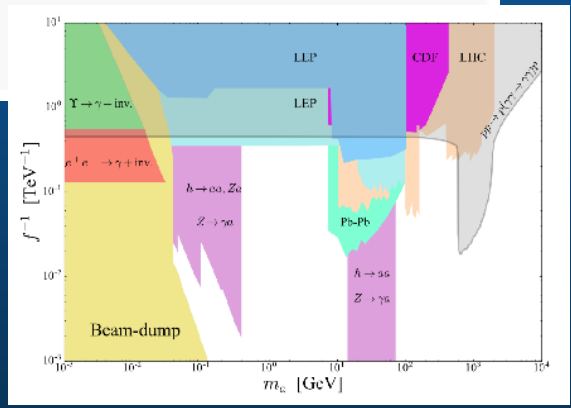
- Using proton tagging, PPS observed $\gamma\gamma \to l^+l^-$ at a 5.1σ level

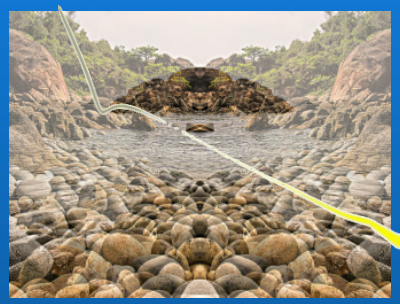


- Possibilities to search for ALPs, Dark Matter, AQGCs, etc. with unprecedented sensitivities
- Opportunities to place limits greater than CMS or ATLAS alone by two orders of magnitude



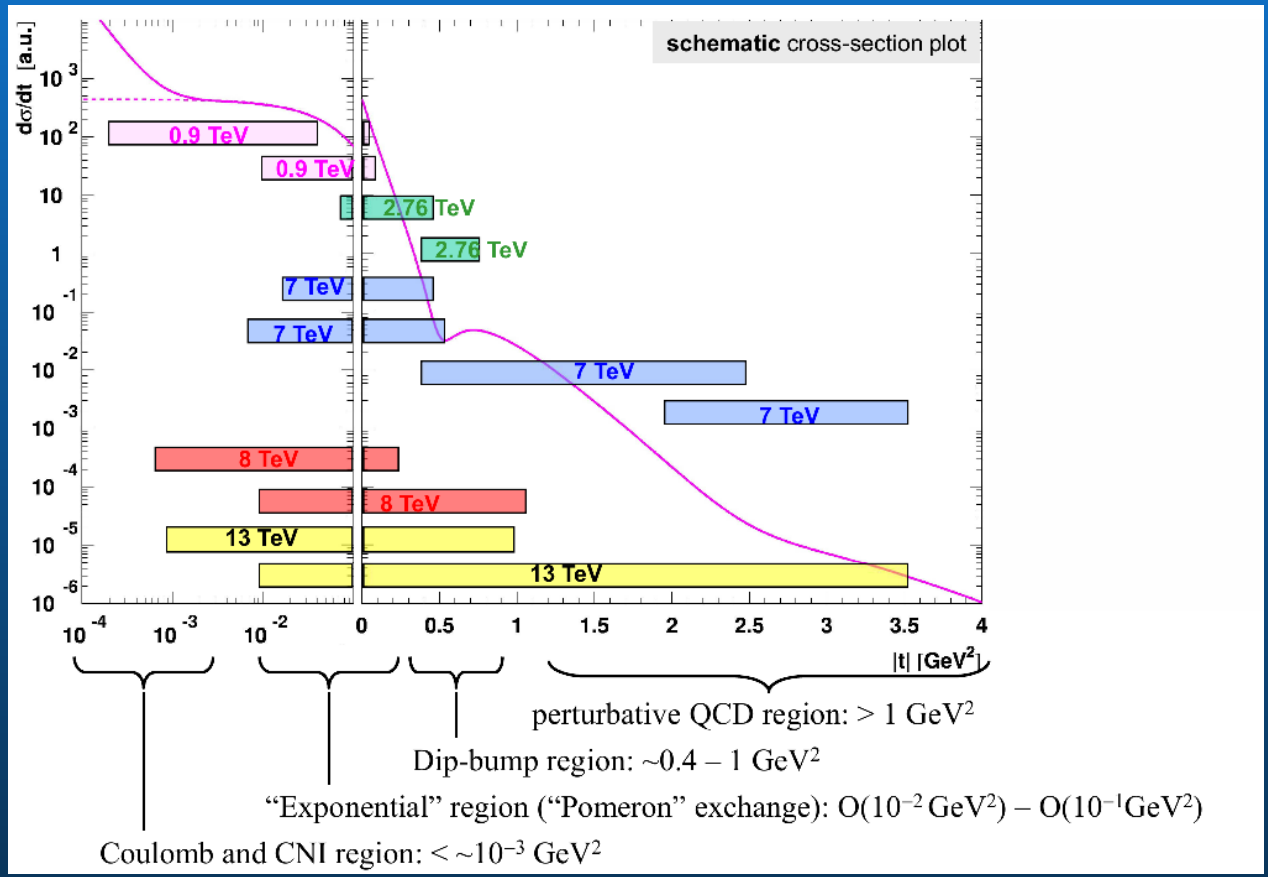


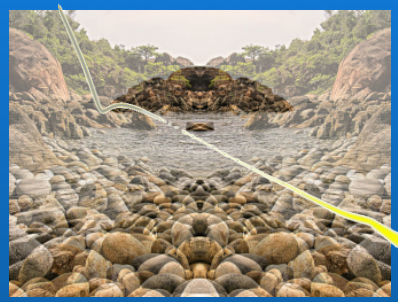




Elastic scattering/total XS

From Mario Diele's talk

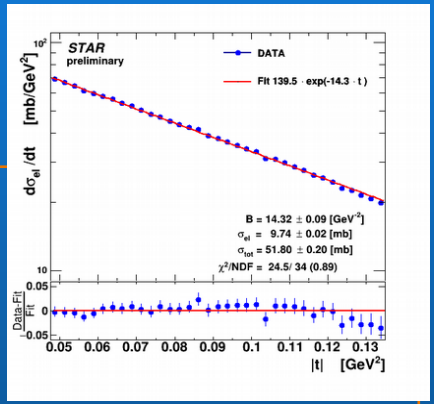


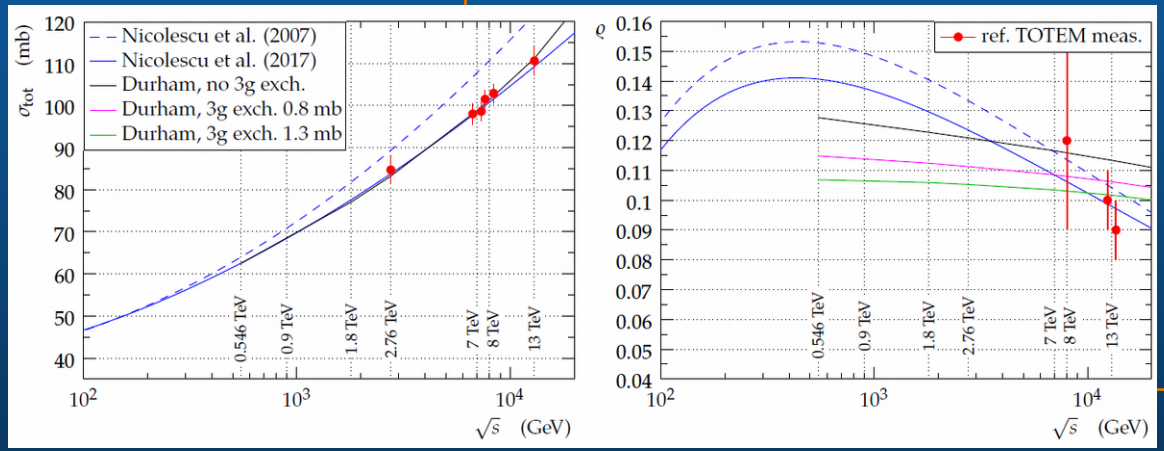


Elastic scattering/total XS

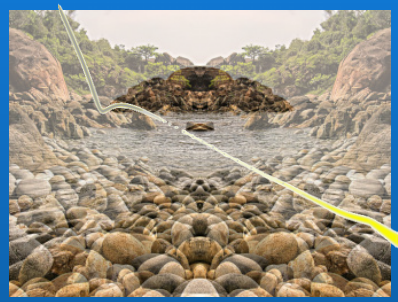
Bogdan Pawlick (STAR)

- Elastic differential cross sections in |t|-range <0.045, 0.135> $(GeV/c)^2$ in pp collisions at $\sqrt{s}$ = 200 GeV.



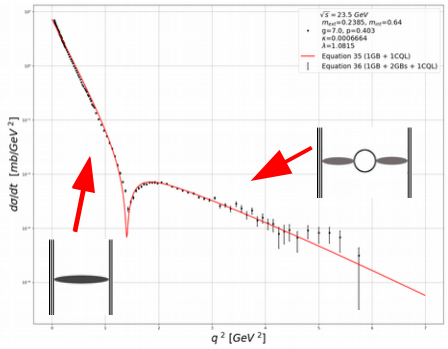


Mario Diele (TOTEM)
- pp XS and rho vs $\sqrt{s}$
- Exchange of a colorless 3-gluon CP-odd "Odderon" in t-channel could decrease rho in pp collisions at large energy



Elastic scattering/total XS

ISR



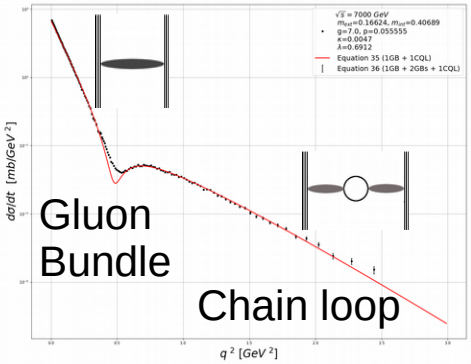
Peter Tsang

- First-principled calculation of elastic proton-proton scattering at ISR and LHC energies. [Fried et al. 1904.11083]
- All gluons exchange summed

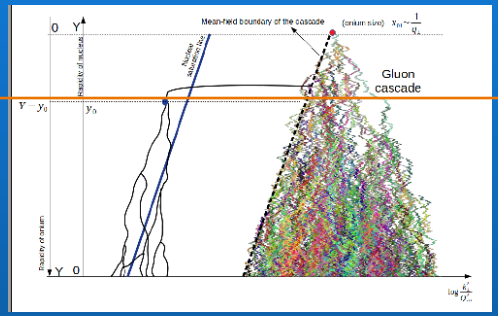
- remarkable fit to differential XS
- disagreement in dip region, interference effects?
- compare to Tevatron.

Will it work?

TOTEM LHC



Diffraction and Elastic Scattering



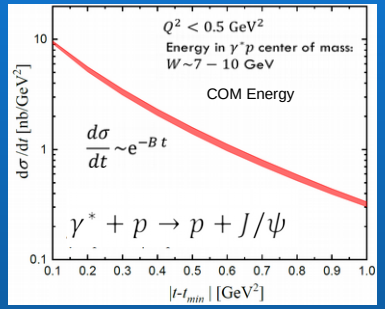
Anh Dung Le: Diffractive onium
- Rap. gap distribution from picture of partonic evolution
- Correspondence between distributions of gap and of splitting time of the first common ancestor.
- Analogy between the genealogy of branching random walk and diffraction.

Nice histories of odderon given

Antoni Szczurek: Odderon exchange in exclusive reactions with φ meson
- Regge phenomenology was extended to 2 → (3,4,6) exclusive processes.
- The tensor pomeron/reggeon model applied to many reactions.

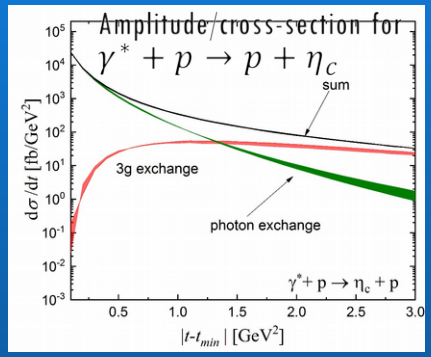
Carlos Contreras: Pomeron numerical solution for BKFL kernel
- Numerical analysis for the Pomeron allowed calculations:
  - Wave function
  - the Pomeron intercept
  - the Pomeron Slopes

Diffraction and Elastic Scattering



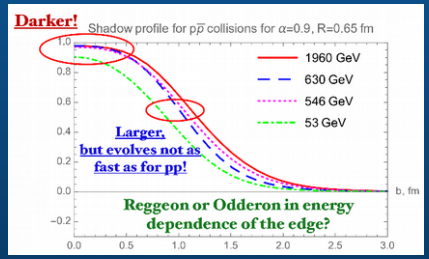
Slope $B \approx 3$ GeV^{-2} in agreement with data

U. Camerini et al., Phys. Rev. Lett. 35, 483 (1975)

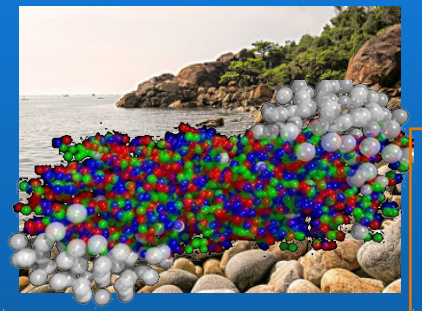


Tomasz Stebel: Pomeron and Odderon: J/psi and η_c electroproduction

Chung-I Tan: Size and Shape of Hadrons...AdS/CFT
- Provide meaning for Pomeron/Odderon non-perturbatively
- First principle description of elastic/total cross sections, DIS at small-x, Central Diffractive Glueball production at LHC, etc.



Roman Pasechnik: Odderon, proton structure and hollowness from the model-independent Levy imaging of elastic hadron-hadron collisions

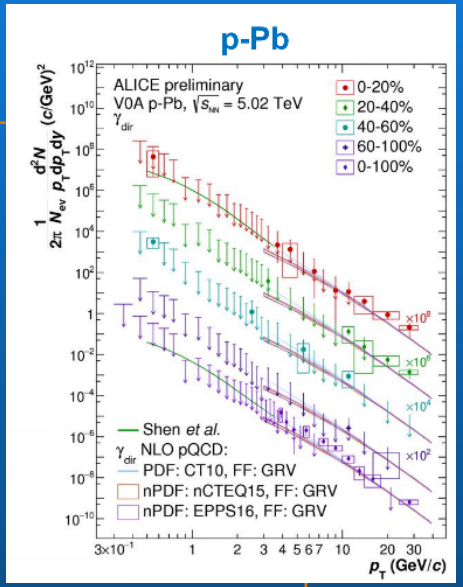


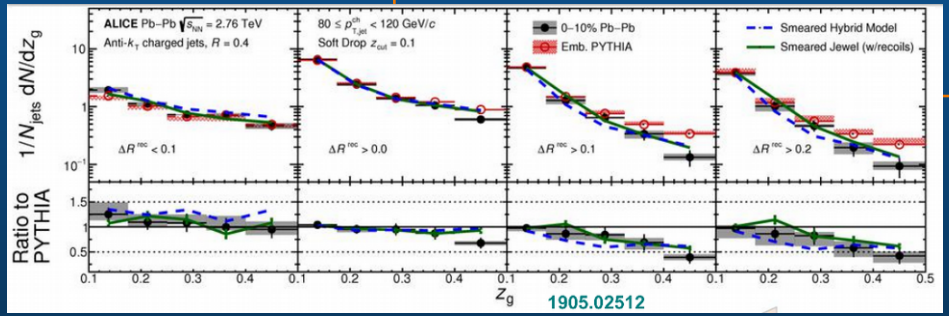
Heavy Ions

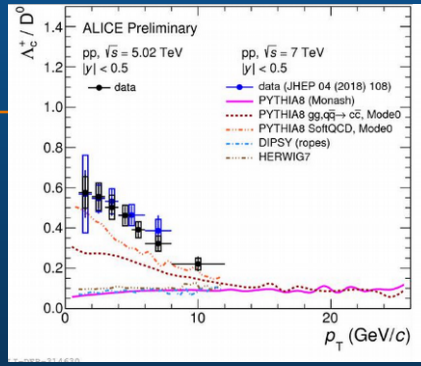
Robert Vertesi

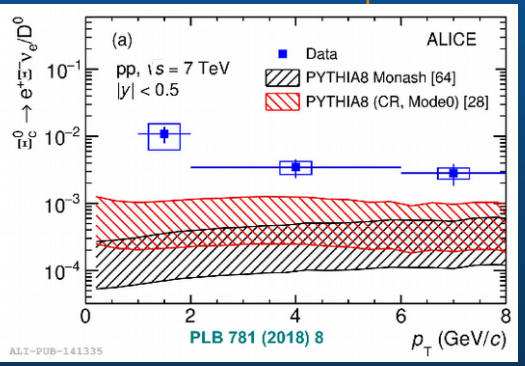
- several new results from ALICE
  - Direct photons in p-Pb collisons
  - Jet substructure in Pb-Pb

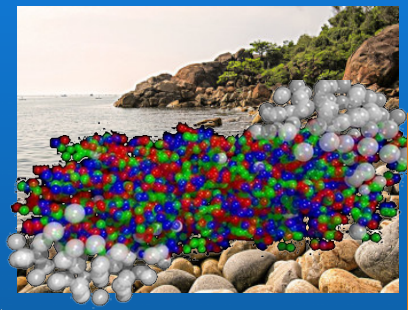
  => influence of medium on jet development
  - Heavy flavor jets in p-Pb
  - Anisotropy of bottomonium: Υ(1S)
  - Charmed baryons in pp: (Λc,Ξc)/D [charm hadronization]



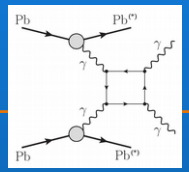




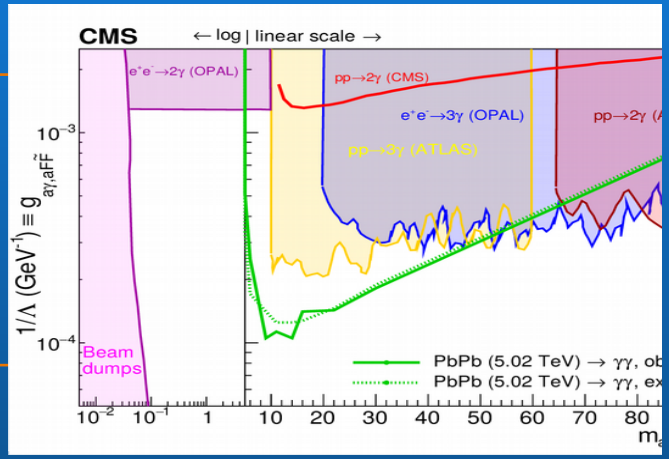


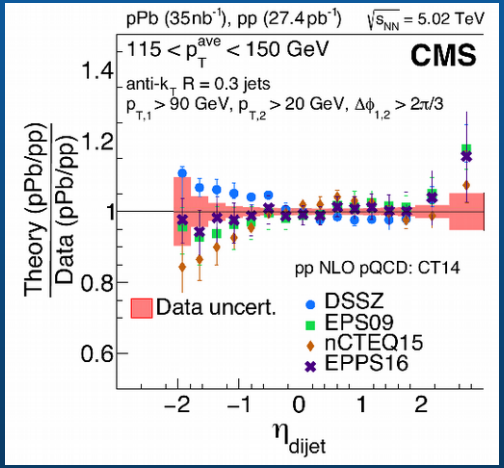


Heavy Ions

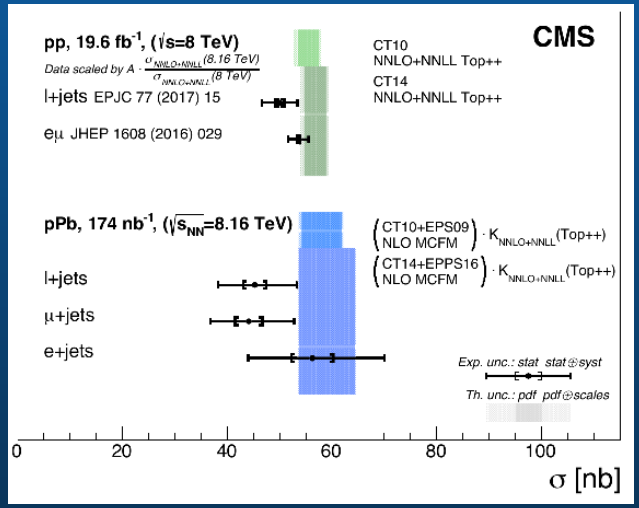


Ruchi Chudasama
- Evidence for light by light scattering, 4.1 (4.4)σ observed (expected)
- Competitive exclusion limits on axion-like particles



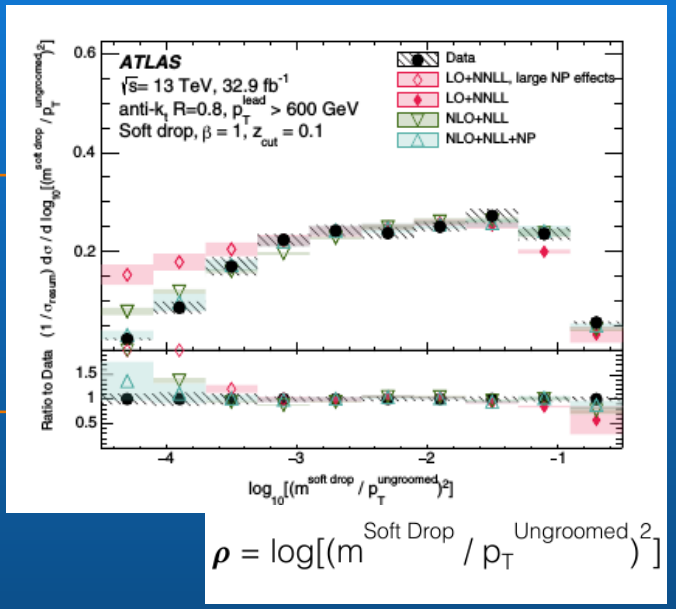


Ramona Vogt
- Improvements in nPDF w/ addition of CMS data
- Hard probes in p+A collisions at LHC and, at higher x, e+A collisions at EIC => better understand nuclear PDFs and cold nuclear matter in general

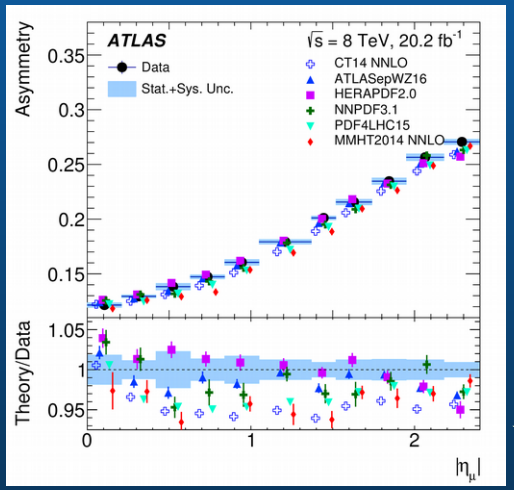


High pT topics

Mario Campanelli (CMS)
- Using SoftDrop algorithm can perform NLO+NNL calculations for substrucure variables, eg “rho”

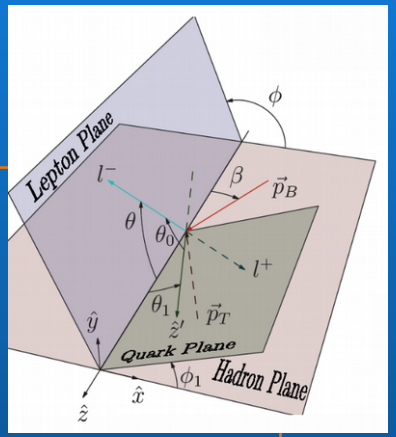


$$\rho = \log[(m^{\text{Soft Drop}} / p_T^{\text{Ungroomed}})^2]$$

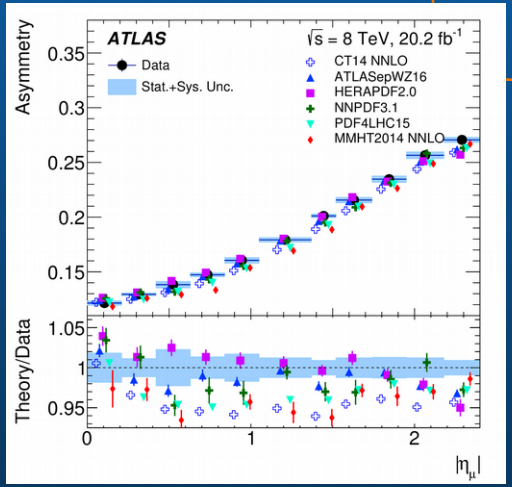


Aleksei Ezhilov (ATLAS)
- The first measurements of W and Z production XS at 5.02 TeV. Systematicly low calculations? Suggestion that s-quark distro may be off?
- Measurements of W XS and charge asymmetry at 8 TeV

High pT topics



Jen-Chieh Peng
- Nice review of Drell-Yan process
- Idea for re-expression of angular coefs in production process
- provides some insights on the origin of qT and rapidity dependencies of the angular distribution coefficients



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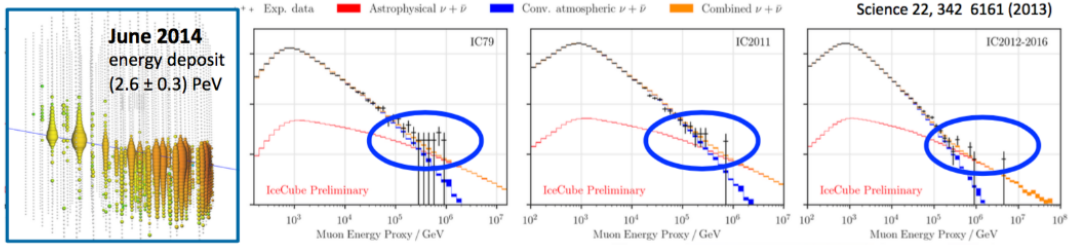
News from ICE Cube

IceCube has discovered a diffuse flux of high-energy (> tens of TeV) astrophysical neutrinos

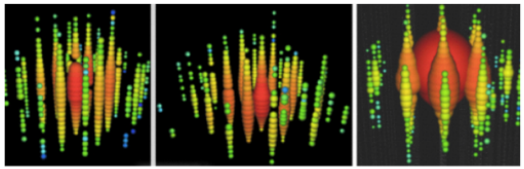
significance **well beyond 5σ** in two independent channels

example: up-going muon neutrino tracks (through-going)

ApJ. 833 (2016)
PRL 113, 101101 (2014)
Science 22, 342 6161 (2013)



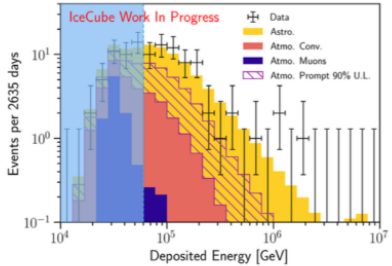
example: high energy starting events



1.0 PeV
August 2011

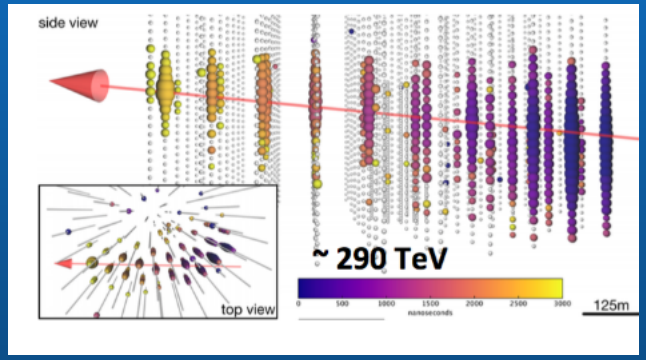
1.1 PeV
January 2012

2 PeV
December 2012



IceCube measures the **energy spectrum and neutrino flavor composition** of this flux hoping to learn about its astrophysical sources (and thus about cosmic ray sources)

Properties are **broadly consistent with** general **astrophysical expectations**
(but many details remain to be understood)



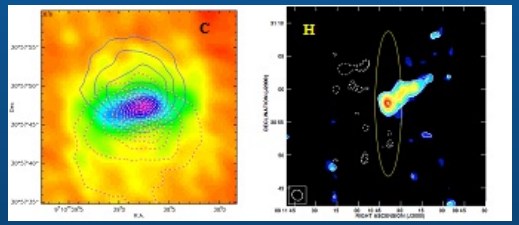
Sources so far evade detection, but

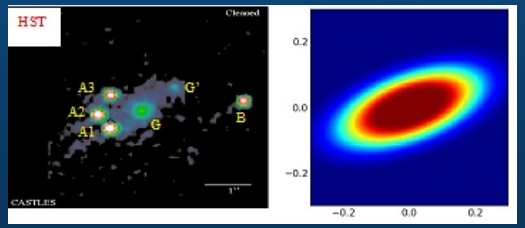
Hans Niederhausen

IceCube in collaboration with γ-ray experiments (Fermi LAT, MAGIC …) potentially (~3σ) **identified** the **blazar TXS 0506+056** as the **first source** of **high energy neutrinos** (and thus cosmic rays)

Science 361 (2018)

Astrophysics in Vietnam





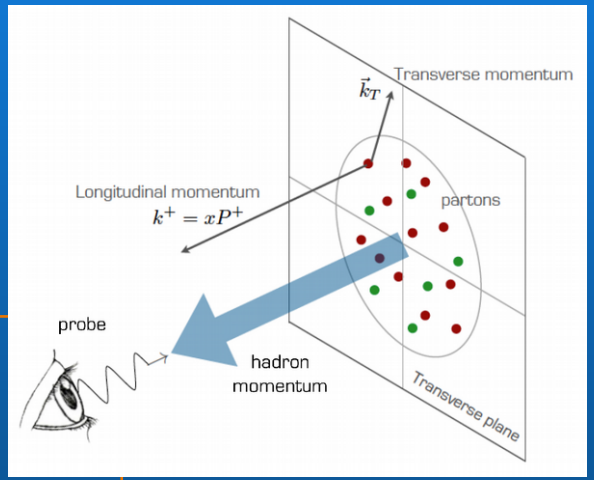
- Over eighteen years (DAP/VSNC) has built a team with expertise in radio astronomy, contributing to research at the international level in stellar physics and in the study of high redshift galaxies.

- The team has gained expertise in interpretation of gravitationally lensed images and in the de-projection of radio interferometer data.

- They make extensive use of opportunities to collaborate internationally and the open data policy of the ALMA collaboration

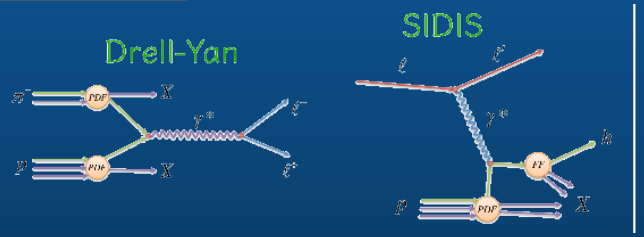
- The growing importance of astrophysics scientific research deserves more prominent to acknowledgment in Vietnam.

3D Imaging of the proton



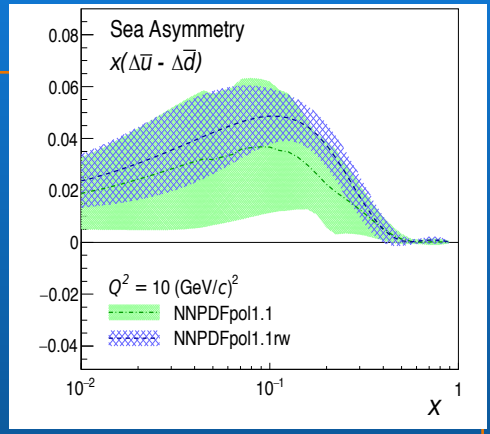
Andrea Signori
- good intro => Transverse-momentum-dependent distributions (TMDs)
- Discussion: flavor dependence of quark intrinsic transverse momentum => (additional) uncertainty in MW measures

Marcia Quaresma: Compass spin results
- nice overview of experiment and measurements
- MANY results on transverse and longitudinal polarised d and p targets

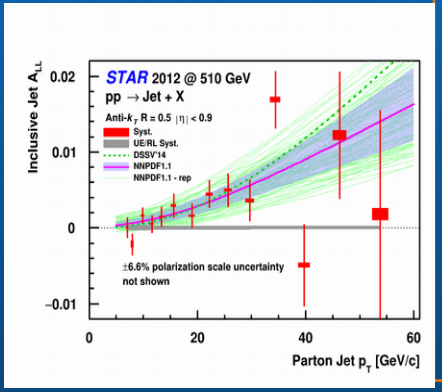


3D Imaging of the proton

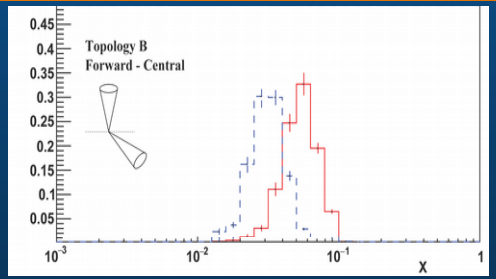
Amilkar Quintero
- New STAR data => Quark Helicity Distributions reduced uncertainty by 40%.
  - First clear evidence of the flavor asymmetry in the polarized quark sea.

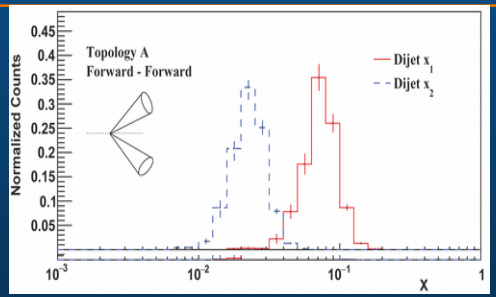


STAR, Phys. Rev. D 99 (2019) 051102



Zilong Chang
- STAR jet double-spin asymmetry A_{LL}. Unique measurements are unique to explore gluon polarization in the proton
- Topological binning to narrow gluon x_g ranges for measurement



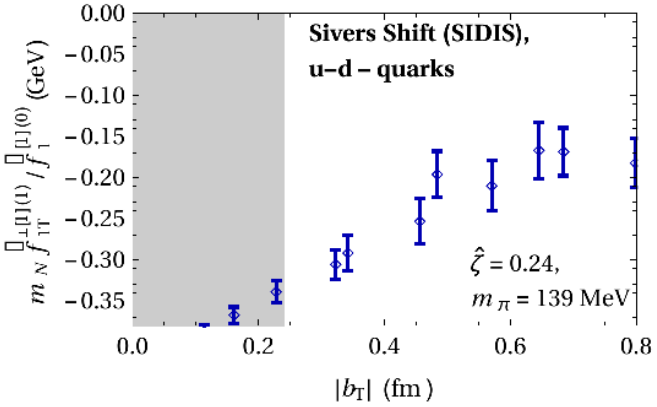


3D Imaging of the proton

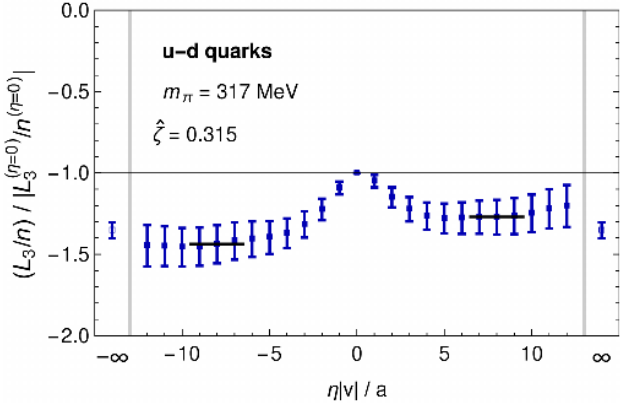
Michael Engelhardt

- Quark transverse dynamics in hadrons from Lattice QCD

Recent progress on quark transverse dynamics in the proton from Lattice QCD

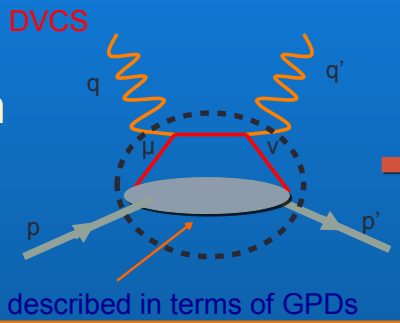


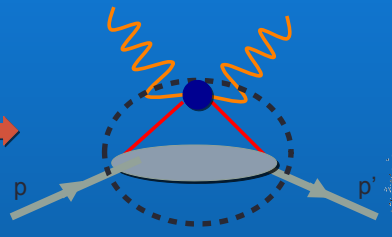
Sivers shift: $\langle k_y \rangle$ of unpolarized quarks in x-polarized proton , generalized to a function of nonlocal operator separation b_T. First data at physical pion mass – Lattice TMD calculations have arrived at the physical point!

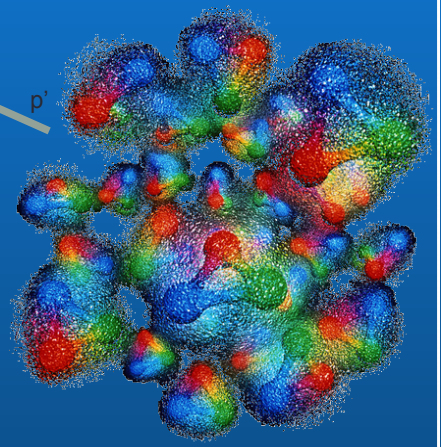


From Ji to Jaffe-Manohar orbital angular momentum: Staple length $\eta|v| = 0$ (straight link) gives Ji OAM, $\eta|v| \to \infty$ gives Jaffe-Manohar OAM. Struck quark picks up torque from final state interactions as $\eta|v|$ rises. Data in units of Ji OAM magnitude.

3D Imaging of the proton







Simonetta Liuti
- GPDs and Deeply Virtual Compton Scattering
- GPDs are key to interpret the mechanical properties of the proton
- Connect the pressure and energy density in neutron stars with collider observables: the GPDs.

From OPE ⟺ From EMT

$$\int dx x H(x,\xi,t) = A_{20}(t) + \xi^2 C_{20}(t) = A(t) + \xi^2 C(t)$$

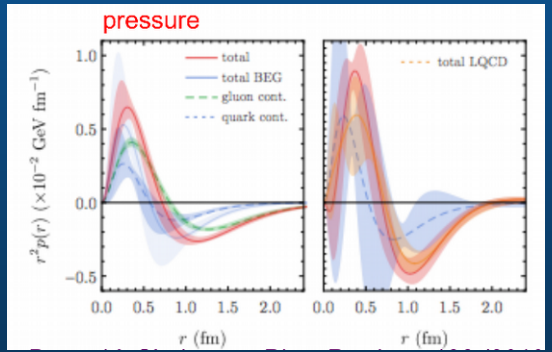
$$\int dx x E(x,\xi,t) = B_{20}(t) - \xi^2 C_{20}(t) = B(t) - \xi^2 C(t)$$

partons momentum

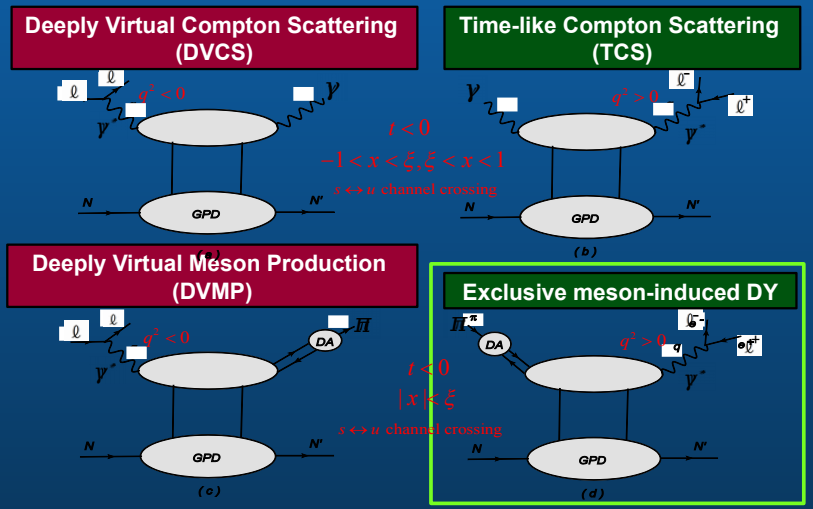
pressure inside proton

2nd Mellin moments

partons angular momentum



3D Imaging of the proton



Wen-Chen Chang: Exclusive Drell-Yan for studying GPDs at J-PARC

- Extraction of GPDs using hadron beams.
- Universality of GPDs in both space-like and time-like processes.

Prospects: with an increase of beam time (50 – 100 days) and beam luminosity and optimization of setup

- GPD at large-Q^2 region
- QCD-evolution properties of GPDs

Many talks conclude they want EIC!

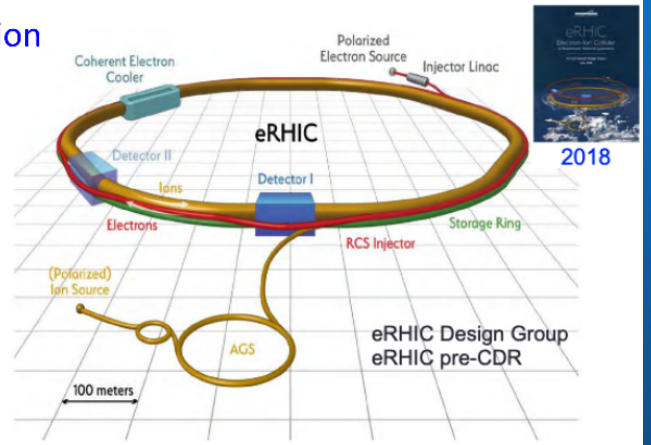
Salvarote Fazio
- Status and prospects of a future EIC

1212.1701.v3
A. Accardi et al
Eur. Phy. J. A, 52 9(2016)

The Electron Ion Collider

Two proposals for realization of the Science Case

Both designs use DOE's significant investments in infrastructure



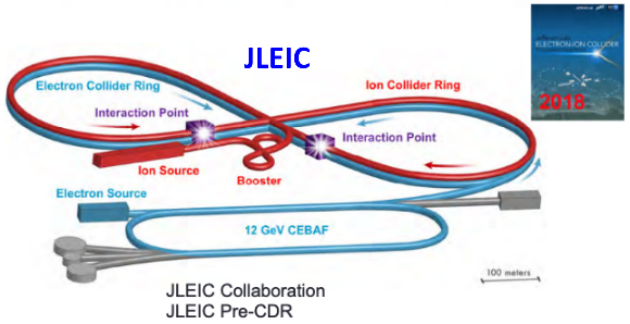
For e-N collisions at the EIC:

- ✓ Polarized beams: e, p, d/^{3}He
- ✓ Luminosity L_{ep} ~ $10^{33\text{-}34}$ cm^{-2}sec^{-1}
  100-1000 times HERA
- ✓ $\sqrt{s}$ = 20-100 (140) GeV Variable CoM

For e-A collisions at the EIC:

- ✓ **Wide range in nuclei**
- ✓ Luminosity per nucleon same as e+p
- ✓ Variable center of mass energy

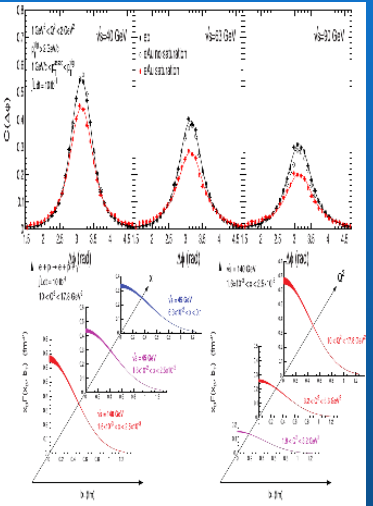
World's first
Polarized electron-proton/light ion
and electron-Nucleus collider

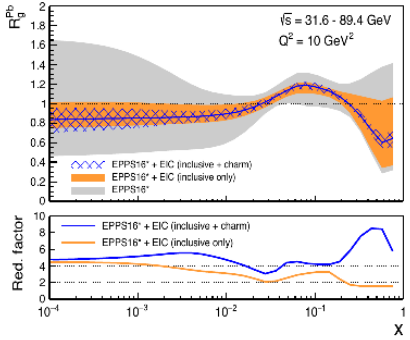


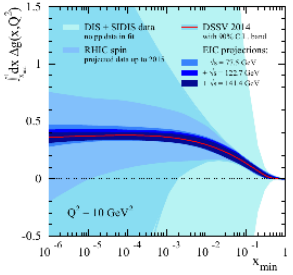
Many talks conclude they want EIC!

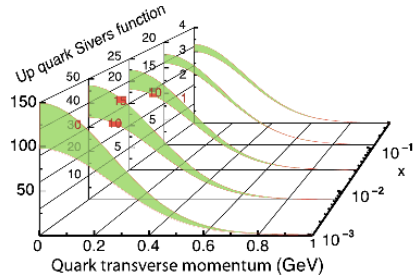
Salvarote Fazio
- Status and prospects of a future EIC

- **An EIC will allow us to obtain the answers to the big questions discussed**
  - ✓ Solve the proton spin puzzle
  - ✓ 3D imaging in momentum and coordinate space of nucleons and nuclei
  - ✓ How visible matter emerges from quarks and gluons?
  - ✓ Map the region of the transition from regimes of non-saturated to saturated gluons

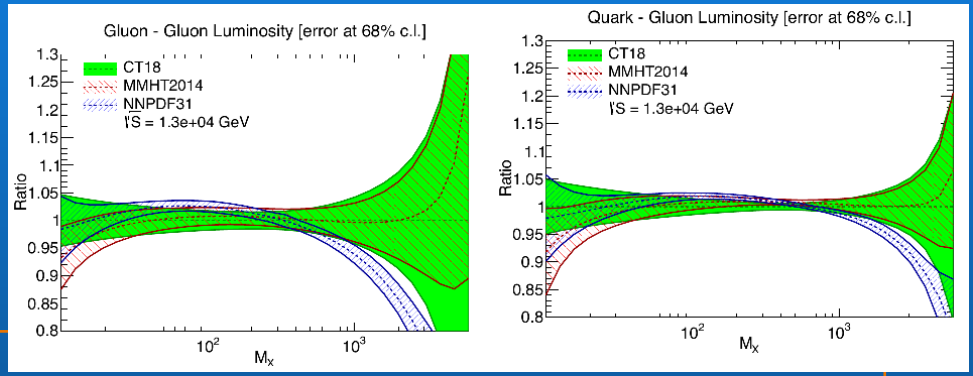








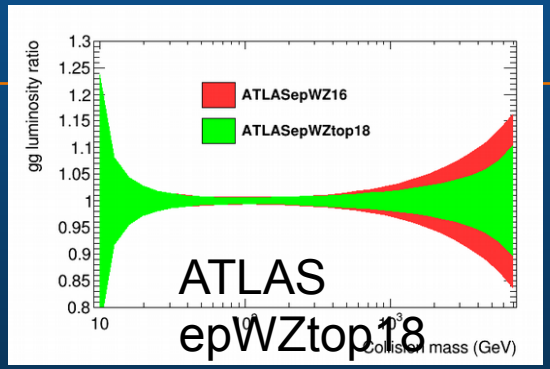
PDFs

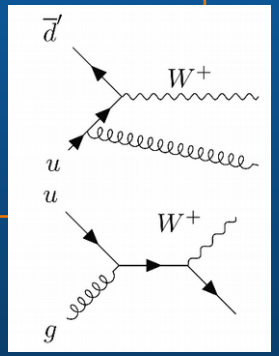


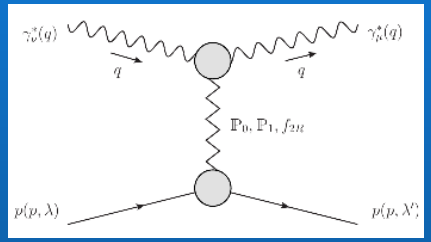
Tie-Jiun Hou
- New CTEQ (CT18) global analysis with high precision data from the LHC

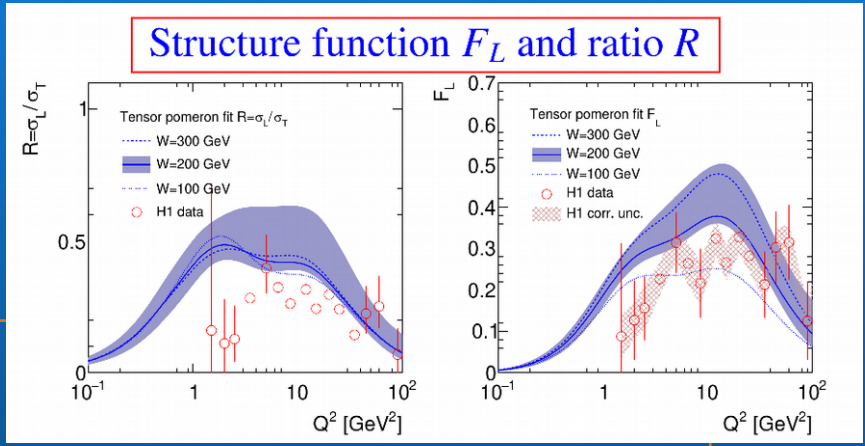
Gavin Pownell: Proton parton distribution functions using ATLAS data
- sensitivity to gluon dist. at lowest order in W+jets

- Constraints in $x \gtrsim 0.05$ region
  - Fits to inclusive W, Z alone $\Rightarrow$ large fluctuations.
  - New W + jets and $t\bar{t}$ 8 TeV data provide significant constraining power.

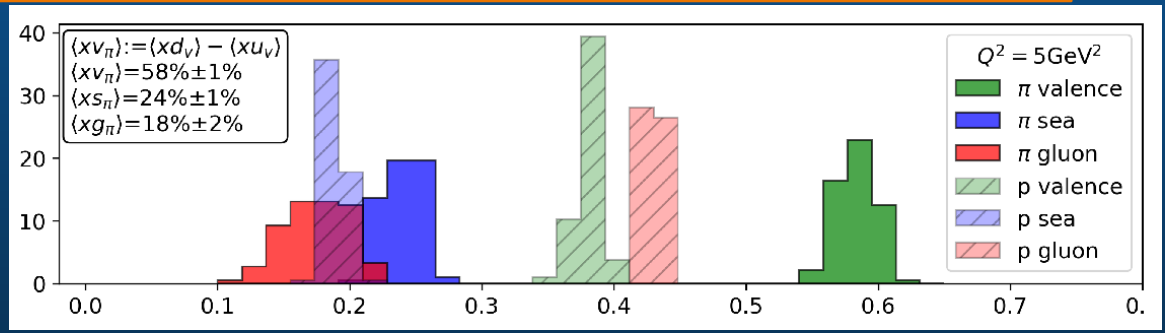




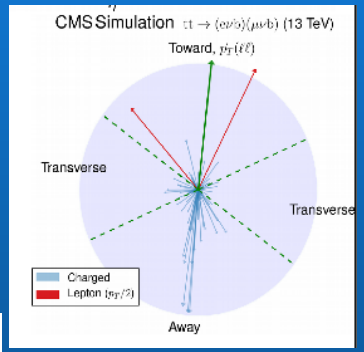


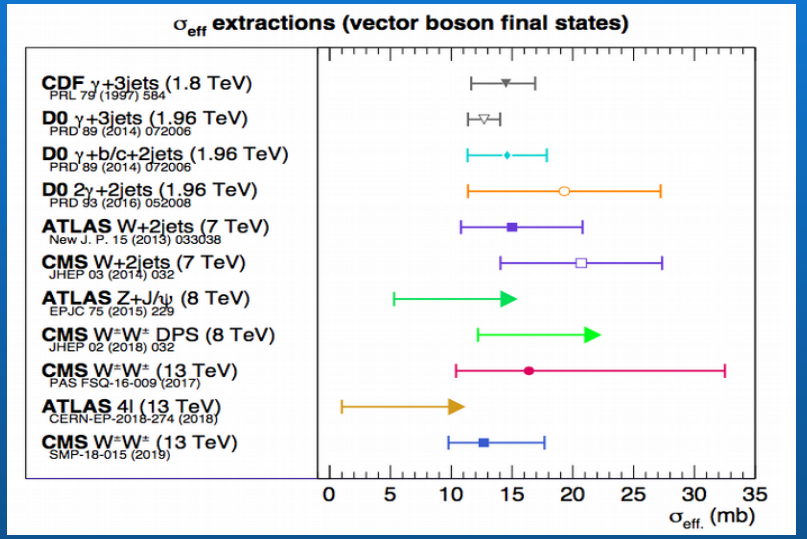


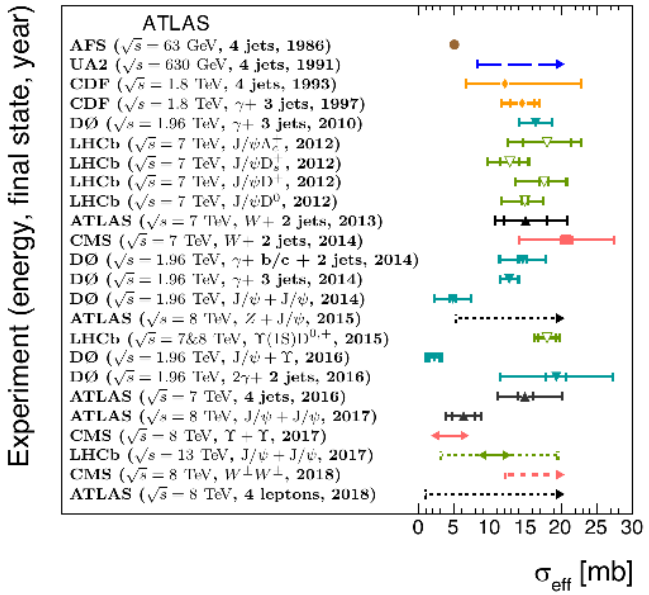
Alexander Glazov:
Recent QCD results from the xFitter project
- Successful fit to the HERA data using tensor pomeron model with two pomerons.
- New application of xfitter machinery to pion PDF
- New applications/analyses in progress



MPI / ULE







Rajat Gupta
Latest results on Soft QCD and DPS @ CMS

Robert Astalos
Multi-parton interactions @ATLAS

Data => Improve ULE MPI tunes

Friday: Theory topics

- Prof. Antoni Szczurek: From quarkonium wave functions to $\gamma^*\gamma^* \rightarrow$ eta_c (1S,2S) transition form factors
- Hongxi Xing: Extracting jet transport coefficient of cold nuclear matter
- Wei Wang: Quasi Parton Distribution Functions for Gluons
- Richard Brower: Quantum Computing and lattice gauge theories
- Daisuke Kadoh: Tensor network in complex scalar theory toward lattice studies of AdS/CFT
- Dr Masanori Hanada: What QCD teaches us about Quantum Gravity, and vise versa

To our conveners and RdV and local staff for making this EDS a success !!!

Let's not forget the 'soft' side of physics that makes our EDS meeting memorable...

If you have photos you wish to share, please send them to:

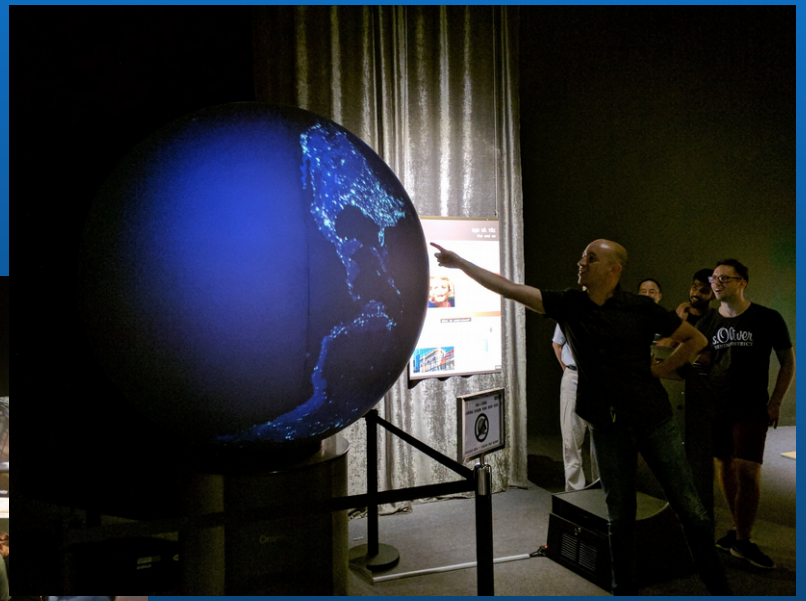
EDSBlois2019@gmail.com

We will make these and photos collected from the conference photographer available via a Google photo album, etc.

Exploring new frontiers together...

… new adventures …

… making new discoveries …



… and many new friends!

From Bob, Christina, Chung-I

Thank you to all the EDS participants for your participation and to TTV and RdV for hosting our conference and all their support behind the scenes.

CONGRATULATIONS on the many excellent results and creative ideas presented this week!

We hope you enjoyed your visit to Quy Nhon and wish you good travels from here.

From Bob, Christina, Chung-I

Thank you to all the EDS participants for your participation and to RdV for hosting our conference and all their sup… the scenes.

CONGRATULATIONS … results and creative ideas present…

Hẹn gặp lại bạn bè!

We hope you enjoyed your visit to Quy Nhon and wish you good travels from here.


BUT WAIT,
there's more!

12 - Session 8: Theoretical developments 2

Antoni Szczurek

ICISE 10:15 - 11:45

Lunch

12:00

ICISE 11:45 - 12:45

13 - Session 9: Conference Summary and Panel Session

13:00

We now turn our agenda over to the session conveners to lead an informal chat about results presented and future prospects

14:00

ICISE 12:45 - 14:30

13 - Session 9: Closing Remarks

Break and departure from ICISE

15:00

ICISE 14:40 - 15:15